

WHAT IS CLAIMED:

1 1. A method, comprising:
2 approximating at least one non-power-of-2 element of a matrix as a power-
3 of-2 element such that all elements of a resultant matrix are power-of-2 elements; and
4 encoding video data using the resultant matrix.

1 2. A method according to Claim 1, wherein the matrix is a DCT
2 (discrete cosine transform) matrix.

1 3. A method according to Claim 1, wherein the approximating includes
2 manipulating an order of the one or more elements in a particular row of the matrix.

1 4. A method according to Claim 1, wherein the approximating includes
2 manipulating the signs of the one or more elements in a particular row of the matrix.

1 5. A method according to Claim 1, wherein the approximating includes
2 manipulating an order and the signs of the one or more elements in a particular row of the
3 matrix.

1 6. A method according to Claim 1, wherein the approximating includes
2 approximating floating point coefficients as power-of-2 coefficients to preserve a
3 threshold relationship between among the floating point coefficients.

1 7. A method according to Claim 1, wherein the approximating includes
 2 approximating floating point coefficients as power-of-2 coefficients to preserve a relative
 3 ratio among the floating point coefficients.

1 8. A method according to Claim 1, wherein V_i ($i = 0-7$) are row vectors
 2 or basis with unity magnitude, s_i are scaling factors, and the resultant matrix is $T = [s_i V_i]^T$,
 3 wherein further V_i are orthogonal to each other and $s_i = 1$.

1 9. A method according to Claim 1, wherein the row vectors of the
 2 resultant matrix are orthogonal.

1 10. A method according to Claim 1, wherein the resultant matrix is
 2
$$T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

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1 11. A method according to Claim 1, wherein the resultant matrix is
 2
$$T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

3 wherein further, for floating point coefficients a, b, c, d, e , and f :
4 $a \geq b \geq c \geq d$ and $e \geq f$,
5 $ab = ac + cd + bd$, and
6 a, b, c, d, e , and f are power-of-2.

1 12. A method according to Claim 11, wherein the resultant matrix is
2 further expressed as the power-of-2 transform matrix:

$$T_3 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 2 & 1 & 2^{-2} & -2^{-2} & -1 & -2 & -2 \\ 2 & 1 & -1 & -2 & -2 & -1 & 1 & 2 \\ 1 & 2^{-2} & -2 & -2 & 2 & 2 & -2^{-2} & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 2 & -2 & -2^{-2} & 1 & -1 & 2^{-2} & 2 & -2 \\ 1 & -2 & 2 & -1 & -1 & 2 & -2 & 1 \\ 2^{-2} & -1 & 2 & -2 & 2 & -2 & 1 & -2^{-2} \end{pmatrix}$$

1 13. A method according to Claim 11, wherein floating point coefficients
2 $a = b = 2, c = 1, d = 1/4, e = 2, f = 1$, and wherein further multiplication for non-integer d is
3 implemented by a two-bit right shift.

1 14. A method according to Claim 11, wherein floating point coefficients
2 $a = 2, b = 2, c = 1, d = 1/2, e = 2, f = 1$, and wherein further multiplication for non-integer d is
3 implemented by a two-bit right shift.

1 15. An image data encoding apparatus, comprising:
2 a transformer to perform a 2-power transform on an incoming array of
3 pixels;
4 a quantizer to quantize the transformer result; and

5 an inverse transformer to perform an inverse 2-power transform on the
6 quantizer result.

1 16. An apparatus according to Claim 15, wherein the transformer is to
2 perform the 2-power transform using a symmetrical matrix in which all elements are
3 expressed as power-of-2 elements.

1 17. An apparatus according to Claim 16, wherein an order of two or
2 more elements in a particular row of the matrix have been changed.

1 18. An apparatus according to Claim 16, wherein the signs of one or
2 more elements in a particular row of the matrix have been changed.

1 19. An apparatus according to Claim 16, wherein the symmetrical
2 matrix is a DCT matrix template.

1 20. An apparatus according to Claim 16, wherein a template of the
2 matrix is

$$3 \quad T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

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1 21. An apparatus according to Claim 16, wherein a template of the
2 matrix is

$$3 \quad T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

4 wherein further, for floating point coefficients a, b, c, d, e , and f :

5 $a \geq b \geq c \geq d$ and $e \geq f$,

6 $ab = ac + cd + bd$, and

7 a, b, c, d, e , and f are power-of-2 coefficients.

1 22. An apparatus according to Claim 16, wherein the matrix is the
2 following power-of-2 transform matrix:

$$3 \quad T_3 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 2 & 1 & 2^{-2} & -2^{-2} & -1 & -2 & -2 \\ 2 & 1 & -1 & -2 & -2 & -1 & 1 & 2 \\ 1 & 2^{-2} & -2 & -2 & 2 & 2 & -2^{-2} & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 2 & -2 & -2^{-2} & 1 & -1 & 2^{-2} & 2 & -2 \\ 1 & -2 & 2 & -1 & -1 & 2 & -2 & 1 \\ 2^{-2} & -1 & 2 & -2 & 2 & -2 & 1 & -2^{-2} \end{pmatrix}$$

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1 23. An apparatus according to Claim 16, wherein V_i ($i = 0-7$) are row
2 vectors or basis with unity magnitude, s_i are scaling factors, and the matrix is $T = [s_i V_i]^T$,
3 wherein further V_i are orthogonal to each other and $s_i=1$.

1 24. An apparatus according to Claim 16, wherein the row vectors of the
2 matrix are orthogonal.

1 25. A computer-readable medium having one or more instructions
2 causing one or more processors to:

3 create a matrix such that all elements in the matrix are expressed as power-
4 of-2 coefficients; and

5 encode video data using the resultant matrix.

1 26. A computer-readable medium according to Claim 25, wherein to
2 create the matrix is to change at least one of an order of one or more elements in a
3 particular row of a template matrix.

1 27. A computer-readable medium according to Claim 25, wherein to
2 create the matrix is to change the sign of at least one element in a particular row of a
3 template matrix.

1 28. A computer-readable medium according to Claim 25, wherein to
2 create the matrix is to approximate floating point coefficients a , b , c , d , e , and f of a
3 template matrix such that:

4 $a \geq b \geq c \geq d$ and $e \geq f$,

5 $ab = ac + cd + bd$, and

6 a , b , c , d , e , and f are power-of-2 coefficients.

1 29. A computer-readable medium according to Claim 28, wherein a
2 template of the matrix

$$3 \quad T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

4 floating point coefficients $a = b = 2$, $c = 1$, $d = 1/4$, $e = 2$, $f = 1$,
5 multiplication for non-integer d is implemented by a two-bit right shift, and

6 wherein the matrix is expressed as the power-of-2 transform matrix:

$$7 \quad T_3 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 2 & 1 & 2^{-2} & -2^{-2} & -1 & -2 & -2 \\ 2 & 1 & -1 & -2 & -2 & -1 & 1 & 2 \\ 1 & 2^{-2} & -2 & -2 & 2 & 2 & -2^{-2} & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 2 & -2 & -2^{-2} & 1 & -1 & 2^{-2} & 2 & -2 \\ 1 & -2 & 2 & -1 & -1 & 2 & -2 & 1 \\ 2^{-2} & -1 & 2 & -2 & 2 & -2 & 1 & -2^{-2} \end{pmatrix}$$

1 30. A computer-readable medium according to Claim 28, wherein a
2 template of the matrix is

$$3 \quad T_2 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ a & b & c & d & -d & -c & -b & -a \\ e & f & -f & -e & -e & -f & f & e \\ c & d & -a & -b & b & a & -d & -c \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ b & -a & -d & c & -c & d & a & -b \\ f & -e & e & -f & -f & e & -e & f \\ d & -c & b & -a & a & -b & c & -d \end{pmatrix}$$

4 floating point coefficients $a=2$, $b=2$, $c=1$, $d=1/2$, $e=2$, $f=1$, multiplication
5 for non-integer d is implemented by a two-bit right shift, and

6 wherein the matrix is expressed as the power-of-2 transform matrix:

7
$$T_3 = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 2 & 1 & 2^{-2} & -2^{-2} & -1 & -2 & -2 \\ 2 & 1 & -1 & -2 & -2 & -1 & 1 & 2 \\ 1 & 2^{-2} & -2 & -2 & 2 & 2 & -2^{-2} & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 2 & -2 & -2^{-2} & 1 & -1 & 2^{-2} & 2 & -2 \\ 1 & -2 & 2 & -1 & -1 & 2 & -2 & 1 \\ 2^{-2} & -1 & 2 & -2 & 2 & -2 & 1 & -2^{-2} \end{pmatrix}$$

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1 31. A computer-readable medium according to Claim 26, wherein the
2 template matrix is a DCT matrix.

1 32. A computer-readable medium according to Claim 27, wherein the
2 template matrix is a DCT matrix.

1 33. A computer-readable medium according to Claim 25, wherein V_i ($i =$
2 0-7) are row vectors or basis with unity magnitude, s_i are scaling factors, and the resultant
3 matrix is $T = [s_i V_i]^T$, wherein further V_i are orthogonal to each other and $s_i = 1$.

1 34. A computer-readable medium according to Claim 25, wherein the
2 row vectors of the resultant matrix are orthogonal.

1 35. An image data encoding apparatus, comprising:
2 means for performing a 2-power transform on an incoming array of pixels;
3 means for quantizing the transformer result; and
4 means for performing an inverse 2-power transform on the quantizer result.